P. . ENT COOPERATION TREA.

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 06 June 2001 (06.06.01)	
International application No. PCT/US00/17414	**Applicant's or agent's file reference** 22188/05931
International filing date (day/month/year) 23 June 2000 (23.06.00)	**Priority date** (day/month/year) 25 August 1999 (25.08.99)
Applicant AMES, Nathan, D. et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

21 March 2001 (21.03.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Claudio Borton
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

10/069,671

PATENT COOPERATION TREATY

PCT

REC'D 28 MAY 2002
WIPO PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

8

Applicant's or agent's file reference 22188/05931	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/US00/17414	International filing date *(day/month/year)* 23 JUNE 2000	Priority date *(day/month/year)* 25 AUGUST 1999
International Patent Classification (IPC) or national classification and IPC IPC(7): B23K 9/00 and US Cl.: 219/137WM, 136, 137R, 74, 75		
Applicant SWAGELOK COMPANY		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets.

   [X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I [X] Basis of the report
   - II [ ] Priority
   - III [ ] Non-establishment of report with regard to novelty, inventive step or industrial applicability
   - IV [ ] Lack of unity of invention
   - V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI [ ] Certain documents cited
   - VII [ ] Certain defects in the international application
   - VIII [ ] Certain observations on the international application

Date of submission of the demand	Date of completion of this report
21 MARCH 2001	18 MARCH 2002
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer M. ALEXANDRA ELVE DEBORAH THOMAS PARALEGAL SPECIALIST Telephone No. (703) 308-0661

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/17414

I. Basis of the report

1. With regard to the elements of the international application:*

☐ the international application as originally filed

☒ the description:
pages (See Attached), as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☒ the claims:
pages (See Attached), as originally filed
pages _____, as amended (together with any statement) under Article 19
pages _____, filed with the demand
pages _____, filed with the letter of _____

☒ the drawings:
pages (See Attached), as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☒ the sequence listing part of the description:
pages (See Attached), as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☒ the description, pages NONE

☒ the claims, Nos. NONE

☒ the drawings, sheets/~~fig~~ NONE

5. ☐ This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

*** Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/17414

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	1-26 & 28-43	YES
	Claims	NONE	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-26 & 28-43	NO
Industrial Applicability (IA)	Claims	1-26 & 28-43	YES
	Claims	NONE	NO

2. citations and explanations (Rule 70.7)

Claims 1-26 & 28-34 lack an inventive step under PCT Article 33(3) as being obvious over Paskell in view of Hummel and Barefoot.

Paskell discloses a flux for gas tungsten arc welding of stainless steels. The flux may contain TiO or TiO2 or Cr2O3 or SiO2. The flux increases the penetration of the weld, decreases the bead width and increases the weld cross sectional area. Further, a method of joining stainless steel components using a thin layer of flux over the joint. Approximate weld parameters are 150A welding current, 9 V welding voltage, about 3 inches per minute welding torch travel speed and a shielding gas of argon flowing at about 25 to 30 cubic feet per hour. Paskell does not disclose the joining of tubular products, welding of duplex stainless steel or the use of orbital welding.

Hummel discloses a method for welding two tubular members together in butting relationship. A purge gas is delivered to the welding zone. It is known that welding of stainless steel products as described by Paskell may encompass stainless steel tubular members as taught by Hummel.

Barefoot discloses the orbital welding pipe materials. It is known that tubular materials may be joined by various methods, one of these being orbital welding.

NEW CITATIONS

US 5,864,111 A (BAREFOOT) 26 January 1999, see entire document

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

I. BASIS OF REPORT:

This report has been drawn on the basis of the description,
page(s) 1-13, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the claims,
page(s) 14--16, as originally filed.
page(s) NONE, as amended under Article 19.
page(s) none, filed with the demand.
and additional amendments:
pages 17-18, filed 26 September 2001

This report has been drawn on the basis of the drawings,
page(s) 1, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the sequence listing part of the description:
page(s) NONE, as originally filed.
pages(s) NONE, filed with the demand.
and additional amendments:
NONE

(c) arc welding the adjacent tube ends together in a single orbital pass using a non-pulsed arc.

30. The process of claim 29, wherein the weld filler is made from a steel containing more austenite than the duplex steel tubes being welded together.

31. The process of claim 30, wherein the filler steel contains more nickel than the forming the duplex steel tubes being welded together.

32. The process of claim 29, wherein the flux includes a metal oxide.

33. The process of claim 29, wherein the weld filler is a weld ring having a T-shaped cross section.

34. The process of claim 29, wherein the arc is continuous.

35. An orbital welding process for joining adjacent ends of two heavy wall duplex stainless steel tubes comprising

(a) applying a high refractory flux to the heat affect zone formed by the adjacent tube ends to be welded, and

(b) arc welding the adjacent tube ends together in a single orbital pass using a non-pulsed arc.

36. The process of claim 29, wherein the flux includes at least one of silica, titania, magnesia, chromia and a titanium oxide.

37. The process of claim 36, wherein the refractory flux comprises a mixture of Cr_2O_3, SiO_2 and an oxide of titanium.

38. The process of claim 37, wherein the refractory flux comprises a mixture of about 30 to 70 wt.% of a titanium dioxide, about 20 to 76 wt.% Cr_2O_3, and about 5 to 27 wt.% SiO_2.

39. The process of claim 38, wherein the wall thickness of the tubing being welded is greater than 2 mm.

40. The process of claim 36, wherein the wall thickness of the tubing being welded is greater than 2 mm.

41. The process of claim 35, wherein the wall thickness of the tubing being welded is greater than 2 mm.

42. The process of claim 35, wherein a weld filler made from a steel containing more austenite than the duplex steel tubes being welded together is placed between the adjacent tube ends to be welded. .

43. The process of claim 42, wherein the weld filler contains more nickel than the duplex steel forming the tubes being welded together.

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: LEONARD L. LEWIS
CALFEE, HALTER & GRISWOLD LLP
1400 MCDONALD INVESTMENT CENTER
800 SUPERIOR AVENUE
CLEVELAND, OHIO 44114

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference 22188/05931	Date of Mailing *(day/month/year)* 17OCT 2000
International application No. PCT/US00/17414	**FOR FURTHER ACTION** **See paragraphs 1 and 4 below**
Applicant SWAGELOK COMPANY	International filing date *(day/month/year)* 23 JUNE 2000

1. [X] The applicant is hereby notified that the international search report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the international search report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in rules 90 *bis* 1 and 90 *bis* 3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer M. ALEXANDRA ELVE DEBORAH THOMAS PARALEGAL SPECIALIST
Facsimile No. (703) 305-3230	Telephone No. (703) 308-0661

Form PCT/ISA/220 (July 1998)★ *(See notes on accompanying sheet)*

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 22188/05931	**FOR FURTHER ACTION**	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/US00/17414	International filing date *(day/month/year)* 23 JUNE 2000	(Earliest) Priority Date *(day/month/year)* 25 AUGUST 1999
Applicant SWAGELOK COMPANY		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readable form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

2. [X] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (See Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. _____

   [ ] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [X] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
S00/17414

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 27
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

IT IS NOT KNOWN WHAT IS MEANT BY 25.10.4.L MATERIAL.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
P[redacted]S00/17414

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B23K 9/00
US CL :219/137WM, 136, 137R, 74, 75
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 219/137WM, 136, 137R, 74, 75

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

USPAT, EPO, JPO, Derwent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,711,474 A (HUMMEL) 27 January 1998, see entire document.	1-26 & 28-34
Y	US 5,804,792 A (PASKELL) 08 September 1998, see entire document	1-26 & 28-34
Y	US 4,952,769 A (ACHESON) 28 August 1990, see entire document	1-26 & 28-34
Y	US 4,683,011 A (WEAVER et al.) 28 July 1987, see entire document.	1-26 & 28-34
Y	US 4,338,142 A (OKUDA et al.) 06 July 1982, see entire document	1-26 & 28-34

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 SEPTEMBER 2000	17OCT 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer M. ALEXANDRA ELVE DEBORAH THOMAS PARALEGAL SPECIALIST Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet) (July 1998)★

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 22188/05931	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/US00/17414	International filing date *(day/month/year)* 23 JUNE 2000	(Earliest) Priority Date *(day/month/year)* 25 AUGUST 1999
Applicant SWAGELOK COMPANY		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of ____ sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

[ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

[ ] contained in the international application in written form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readable form.

[ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the

[ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

2. [X] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (See Box II).

4. With regard to the **title**,

[X] the text is approved as submitted by the applicant.

[ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

[X] the text is approved as submitted by the applicant.

[ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. ____

[ ] as suggested by the applicant.

[ ] because the applicant failed to suggest a figure.

[ ] because this figure better characterizes the invention.

[X] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PC[redacted]0/17414

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 27
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

IT IS NOT KNOWN WHAT IS MEANT BY 25.10.4.L MATERIAL.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ 17414

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B23K 9/00
US CL :219/137WM, 136, 137R, 74, 75

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 219/137WM, 136, 137R, 74, 75

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

USPAT, EPO, JPO, Derwent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,711,474 A (HUMMEL) 27 January 1998, see entire document.	1-26 & 28-34
Y	US 5,804,792 A (PASKELL) 08 September 1998, see entire document	1-26 & 28-34
Y	US 4,952,769 A (ACHESON) 28 August 1990, see entire document	1-26 & 28-34
Y	US 4,683,011 A (WEAVER et al.) 28 July 1987, see entire document.	1-26 & 28-34
Y	US 4,338,142 A (OKUDA et al.) 06 July 1982, see entire document	1-26 & 28-34

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 SEPTEMBER 2000	17OCT 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer M. ALEXANDRA ELVE DEBORAH THOMAS PARALEGAL SPECIALIST Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet) (July 1998)★

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: JOHN E. MILLER
CALFEE, HALTER & GRISWOLD LLP
1400 MCDONALD INVESTMENT CENTER
800 SUPERIOR AVENUE
CLEVELAND, OHIO 44114

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of Mailing *(day/month/year)*	23 MAY 2002
Applicant's or agent's file reference: 22188/05931	IMPORTANT NOTIFICATION

International application No.	International filing date *(day/month/year)*	Priority Date *(day/month/year)*
PCT/US00/17414	23 JUNE 2000	25 AUGUST 1999

Applicant
SWAGELOK COMPANY

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer M. ALEXANDRA ELVE DEBORAH THOMAS PARALEGAL SPECIALIST Telephone No. (703) 308-0661

Form PCT/IPEA/416 (July 1992)★

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 22188/05931	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US00/17414	International filing date *(day/month/year)* 23 JUNE 2000	Priority date *(day/month/year)* 25 AUGUST 1999
International Patent Classification (IPC) or national classification and IPC IPC(7): B23K 9/00 and US Cl.: 219/137WM, 136, 137R, 74, 75		
Applicant SWAGELOK COMPANY		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets.

   [X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I [X] Basis of the report
   - II [ ] Priority
   - III [ ] Non-establishment of report with regard to novelty, inventive step or industrial applicability
   - IV [ ] Lack of unity of invention
   - V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI [ ] Certain documents cited
   - VII [ ] Certain defects in the international application
   - VIII [ ] Certain observations on the international application

Date of submission of the demand 21 MARCH 2001	Date of completion of this report 18 MARCH 2002
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer M. ALEXANDRA ELVE DEBORAH THOMAS PARALEGAL SPECIALIST Telephone No. (703) 308-0661

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/17414

I. Basis f the report

1. With regard to the elements of the international application:*

☐ the international application as originally filed

☒ the description:
pages (See Attached) , as originally filed
pages , filed with the demand
pages , filed with the letter of

☒ the claims:
pages (See Attached) , as originally filed
pages , as amended (together with any statement) under Article 19
pages , filed with the demand
pages , filed with the letter of

☒ the drawings:
pages (See Attached) , as originally filed
pages , filed with the demand
pages , filed with the letter of

☒ the sequence listing part of the description:
pages (See Attached) , as originally filed
pages , filed with the demand
pages , filed with the letter of

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☒ the description, pages NONE

☒ the claims, Nos. NONE

☒ the drawings, sheets/~~fig~~ NONE

5. ☐ This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

***Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/17414

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	1-26 & 28-43	YES
	Claims	NONE	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-26 & 28-43	NO
Industrial Applicability (IA)	Claims	1-26 & 28-43	YES
	Claims	NONE	NO

2. citations and explanations (Rule 70.7)

Claims 1-26 & 28-34 lack an inventive step under PCT Article 33(3) as being obvious over Paskell in view of Hummel and Barefoot.

Paskell discloses a flux for gas tungsten arc welding of stainless steels. The flux may contain TiO or TiO2 or Cr2O3 or SiO2. The flux increases the penetration of the weld, decreases the bead width and increases the weld cross sectional area. Further, a method of joining stainless steel components using a thin layer of flux over the joint. Approximate weld parameters are 150A welding current, 9 V welding voltage, about 3 inches per minute welding torch travel speed and a shielding gas of argon flowing at about 25 to 30 cubic feet per hour. Paskell does not disclose the joining of tubular products, welding of duplex stainless steel or the use of orbital welding.

Hummel discloses a method for welding two tubular members together in butting relationship. A purge gas is delivered to the welding zone. It is known that welding of stainless steel products as described by Paskell may encompass stainless steel tubular members as taught by Hummel.

Barefoot discloses the orbital welding pipe materials. It is known that tubular materials may be joined by various methods, one of these being orbital welding.

NEW CITATIONS

US 5,864,111 A (BAREFOOT) 26 January 1999, see entire document

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

I. BASIS OF REPORT:

This report has been drawn on the basis of the description,
page(s) 1-13, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the claims,
page(s) 14--16, as originally filed.
page(s) NONE, as amended under Article 19.
page(s) none, filed with the demand.
and additional amendments:
pages 17-18, filed 26 September 2001

This report has been drawn on the basis of the drawings,
page(s) 1, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the sequence listing part of the description:
page(s) NONE, as originally filed.
pages(s) NONE, filed with the demand.
and additional amendments:
NONE

(c) arc welding the adjacent tube ends together in a single orbital pass using a non-pulsed arc.

30. The process of claim 29, wherein the weld filler is made from a steel containing more austenite than the duplex steel tubes being welded together.

31. The process of claim 30, wherein the filler steel contains more nickel than the forming the duplex steel tubes being welded together.

32. The process of claim 29, wherein the flux includes a metal oxide.

33. The process of claim 29, wherein the weld filler is a weld ring having a T-shaped cross section.

34. The process of claim 29, wherein the arc is continuous.

APPARATUS AND METHOD FOR WELDING DUPLEX STAINLESS STEEL

Cross-Reference to Related Application

The present application is based on United States Provisional Application SN 60/150,738, filed August 25, 1999, the benefit of which is hereby claimed. The disclosure of this application is also incorporated herein by reference.

Technical Field of the Invention

The present invention relates to welding processes for duplex stainless steels. More particularly, the invention relates to the use of a flux, and optionally a weld ring, to weld duplex stainless steel using, for example, an orbital welder.

Background of the Invention

Duplex stainless steel is becoming more widely used in applications that require high strength and corrosion resistance. A typical example is deep sea applications in the oil and gas industry. Particularly for high pressure operations, thick walled or heavy duplex tubing may be required. By "thick walled" or "heavy" tubing, which are used interchangeably herein, is meant duplex tubing greater than 2 mm wall thickness. For most applications, duplex tubing is welded either to additional sections of duplex tubing or to fittings, valves and so forth all of which may be made of duplex steel.

Duplex steel is characterized by a phase balance between austenite and ferrite in the steel crystalline structure. In general, duplex stainless steels contain about 30 to 70 vol.% ferrite, more typically about 35 to 60 vol.% ferrite, even more typically about 40 to 45 vol.% ferrite, with the balance being

austenite. Maintaining the austenite/ferrite phase balance is very important in that the austenitic phase contributes to the pitting corrosion resistance of the steel while the ferrite phase contributes to greater strength and resistance to chloride stress corrosion cracking.

Welding of duplex steels presents special challenges, since a proper phase balance and nitrogen content must be maintained in the weld metal as well as in the surrounding heat affect zone (HAZ). This is because welding subjects the material forming the weld bead to additional high heat, melting, cooling and solidification. Many factors associated with the welding process can affect the phase balance in the weld metal. These factors include the welding temperature, cooling rate, type of purge gas used during the welding operation and the chemistry of the weld pool. If the final weld solidifies with too much austenite, the strength of the weld can be compromised. If the weld solidifies with too much ferrite, the weld and HAZ may exhibit lower corrosion resistance.

Welding of steel tubing is done both manually and by machine. In both operations, sagging or drop through of the weld pool should be avoided so that the weld bead is uniform in profile along its entire length. In addition, the weld bead should not be too wide in profile, since a weld bead which solidifies too slowly may exhibit improper metallurgy in terms of both chemistry and phase structure. Incomplete penetration through the tube wall should also be avoided.

Machine welding of steel tubing is typically done commercially using orbital welding equipment in which heat for welding is derived from an electric arc generated by a pulsed electric current. The arc emanates from an electrode

positioned outside the tubing adjacent the weld junction to be formed, with the electrode being moved by the machine orbitally (circumferentially) around the tubing along its entire circumference. Preferably, orbital welding is accomplished in a single pass (plus an additional 30° to 120° in some instances to complete the weld smoothly), since this approach minimizes problems occurring when a previously formed weld bead is remelted.

Thick walled duplex tubing is particularly difficult to weld, since the factors causing poor weld profile and improper phase balance magnify as tube wall thickness increases. Therefore, it has not been possible to achieve acceptable weld quality when machine welding duplex steel tubing of heavy wall thickness. Although manual welding can achieve acceptable weld quality, a highly skilled welder is required. Moreover, multiple weld passes are also required, which only exacerbates the complexity and expense of the welding process.

It is, therefore, an object of the present invention to provide welding apparatus and methods that significantly improve the weldability of duplex stainless steel by producing acceptable weld profiles and weld beads exhibiting a proper duplex phase balance and nitrogen retention.

It is a further object of the present invention to provide a welding process and apparatus that facilitate machine based welding, especially single pass orbital welding, of duplex stainless steel tubing, especially thick walled duplex stainless steel tubing.

Summary of the Invention

In accordance with the present invention, it has been found that duplex steel tubing and other parts can be easily joined by machine based arc welding provided that a high-refractory flux is present in the HAZ (heat affected zone) and further that the electric arc generated for welding is non-pulsed. In particular, it has been found that the weld bead produced when welding duplex steel parts together will reliably and consistently achieve the desired duplex phase balance, nitrogen levels and bead profile if a high-refractory flux is present in the HAZ, provided that the arc supplying the weld heat is generated by a non-pulsed electric current.

Accordingly, the present invention in its broader aspects provides a new process for welding duplex steel parts in which formation of a weld bead having a duplex stainless steel phase structure is facilitated by carrying out the welding operation in the presence of a high refractory flux. In addition, the present invention also provides a new process for arc welding duplex steel tubing in which a weld bead having a duplex stainless steel phase structure, a desired nitrogen level and a uniform profile is achieved by carrying out welding in the presence of a high refractory flux with the heat for welding being derived from an arc generated by a non-pulsed electric current.

Brief Description of the Drawing

The invention may take physical form in certain parts and arrangements of parts, preferred embodiments and a method of which will be described in detail in this specification and illustrated in the accompanying drawing which form a part hereof, and wherein is illustrated an apparatus for welding duplex steel thick walled tubing.

Detailed Description of the Preferred Embodiments

The present invention can be used for welding a wide variety of parts together that are made of duplex stainless steel, especially but not necessarily thick walled or heavy duplex tubing and tube ends. In particular, the present invention is directed to welding together two or more parts, at least one of which is formed from a duplex steel, and further in which the weld bead formed by the welding operation also has a duplex structure.

As mentioned above, duplex stainless steels contain about 30 to 70 vol.% ferrite, more typically about 35 to 60 vol.% ferrite, even more typically about 40 to 45 vol.% ferrite, with the balance being austenite. The weld beads produced by the inventive process also have a duplex stainless steel phase structure, meaning they also contain these amounts of austenite and ferrite, since this balance of phases is needed to achieve the high strength and corrosion resistance characteristic of duplex steels.

In accordance with the present invention, it has been found that a weld bead having the above desired phase balance and nitrogen levels, as well as an appropriate profile, can be formed when welding duplex steel, provided that a high-refractory flux is present in the HAZ and the electric arc used for supplying the welding heat is non-pulsed.

Weld fluxes are well known products of commerce extensively used in the welding industry. Basically, they serve as surface active agents causing the molten weld pool to flow in a desired manner, i.e. to amalgamate or consolidate along the surface being heated into a compact mass. The effectiveness of a weld flux in promoting consolidation of a weld pool is measured in terms of

penetration characteristic of the weld, which is the ratio of the weld depth to its width at its widest point. In accordance with the present invention, welds can be produced with penetration coefficients of 0.33 or greater, preferably 0.5 or greater, more preferably 1.0 or greater.

Many different materials have been used for weld fluxes. Most typical are chlorides and fluorides such as magnesium chloride, ferric chloride, tin chloride and various sulfur containing compounds. In accordance with the present invention, we have discovered that these typical weld fluxes are ineffective in achieving a duplex weld bead with the desired phase balance and profile. In particular, we have determined that such fluxes contaminate the weld pool with extraneous materials such as chloride, fluoride and/or sulfur atoms, thereby adversely affecting the phase balance and chemistry of the weld bead ultimately produced. In the present invention, therefore, a different type of weld flux is used, referred to herein as "high refractory" fluxes.

A high refractory flux in accordance with the present invention is any material which will impart surface active properties to the weld pool which it contacts in the manner of conventional welding fluxes, but which also does not contaminate the molten weld pool with extraneous atoms as a result of the welding operation. Examples of materials which are useful for this purpose are the refractory oxides such as silica, titania, magnesia, chromia, TiO, and the like. An especially preferred weld flux is composed of a mixture of Cr_2O_3, SiO_2 and an oxide of titanium, particularly a mixture of about 30 to 70 wt.% of a titanium oxide (TiO and/or TiO_2), 20 to 76 wt.% Cr_2O_3 and 5 to 27 wt.% SiO_2, as described in US Patent No. 5,804,792, the disclosure of which is incorporated

herein by reference. A flux comprising about 50% oxide of titanium, about 40% Cr_2O_3 and about 10% SiO_2 is especially preferred. Generally, such fluxes are supplied in admixture with a liquid carrier such as water or an organic material such as acetone or methyl ethyl ketone. An exemplary flux of this type is LFX-SS7 flux available from Liburdi Dimetrics Company of Dundas, Ontario, Canada.

These fluxes are used in accordance with the present invention in the same way as conventional welding fluxes. Thus they may be applied in the same amounts, to the same locations, and at the same time, as conventional fluxes. Where a weld ring is used, in accordance with a preferred embodiment of the invention as describe below, the weld flux may be applied to the weld ring only, before or after the weld ring is joined to the tubes being welded, or it may be applied the tubes themselves, or to both the weld ring and the tubes.

Once the weld flux is applied, the duplex parts to be joined are welded in a conventional manner. Where welding is accomplished by arc welding, it is preferable in accordance with the present invention to use non-pulsed welding — i.e., arc welding in which the electric current generating the arc is non-pulsed, preferably continuous. In a typical orbital welding operation, pulsed electrode currents are used because they are easier to regulate and to use to control heat at the weld zone. However, we have found that weld beads produced with pulsed arcs are unacceptably porous and non-uniform if a high refractory weld flux, as described above, is present during welding. Although not wishing to be bound to any theory, we believe unacceptable welds are produced when pulsed arcs are used together with high refractory fluxes

because of excessive turbulence created in the weld pool. Non-pulsed arcs smooth out the rate heat is applied and thereby reduce or eliminate excessive heat generation and attendant turbulence during peaks in the electrical cycle.

In standard arc welding, current pulsing occurs at 2 to 20 Hertz, typically, with amplitudes generally varying between 100% and 30% of peak. "Non-pulsed" as used herein means that the period of the pulse is lengthened and/or the variation between maximum and minimum amplitude is reduced so that violent turbulence and it attendant adverse effect on weld quality is substantially eliminated. Preferably, direct (continuous) current is used, as this completely eliminates the adverse effects of pulsing. Using non-pulsed arcs in accordance with the present invention has also be found to reduce the total amount of electrical power required for welding.

A particular advantage of the present invention is that high quality welds having the desired austenite/ferrite balance, nitrogen levels and bead profile can be produced in a single electrode pass, even if the wall thickness of the tubing being welded exceeds 2 mm. Orbital welding of duplex steel tubing using conventional technology is difficult at best and impossible, as a practical matter, when the wall thickness of the tubing exceeds 2 mm. Welding duplex tubing of this thickness manually is possible, but very difficult, and in any event multiple passes are required. In accordance with the present invention, however, tubing of this thickness can be readily welded together with conventional orbital welders even when the welders are operated in a single pass mode. In this connection, it should be understood that single pass operation as contemplated herein includes extending the pass of the electrode by an additional 30, 45, 90,

120 or even 180 degrees beyond a single complete revolution in order to smooth out completion of the weld. Good results, however, can still be accomplished with a single pass of 360 degrees.

In accordance with another embodiment of the invention, the weld pool is formed using additional alloy elements supplied by a weld filler material. Using weld fillers to supply additional alloying elements to a weld is a common welding practice. Since the metallurgy of a weld can often be different from that of the underlying base metal, additional alloying elements supplied by a weld filler can be used to alter the chemistry of the weld so as to achieve a more desirable chemistry and metallurgy. This effect can be used in welding duplex steels in accordance with the present invention to tailor the austenite/ferrite balance of the weld bead produced closer to a desired value.

In this connection, welds produced form duplex steels tend to have a lower proportion of austenite than the base metals from which they are melted. Therefore, this effect can be offset, and the desired phase balance maintained, at least approximately, by using a weld filler whose alloying elements tend to promote austenite formation. Nickel helps stabilize or enhance austenite formation during solidification, while chromium fosters ferrite formation. Therefore, using a weld filler that is over alloyed with nickel compared to the base metal being welded is a desirable approach in accordance with the present invention. For example, a weld filler made of 25.10.4.L filler material available from Sandvik Corporation can be used advantageously for welding 2507 duplex stainless steel also available from Sandvik.

Weld filler materials in accordance with this aspect of the invention can be supplied in any conventional manner. For example, they can be supplied in the form of wire, for use in manual as well as machine based welding, or they can be supplied in the form of weld rings for insertion between and attachment to the ends of the tubes being welded. Preferably, the weld filler is supplied in the form of a weld ring T-shaped in profile since this allows the tube ends to be physically secured together before welding. Also, if desired, the high refractory flux to be used in the inventive process can be applied to the weld ring separately from the tube ends to be welded before or after the weld ring is attached to the tubing to be welded. Indeed, the ingredients of the high refractory flux can even be incorporated into the weld ring when it is made, if desired.

Orbital welding can be carried out using an open system, that is apparatus in which the gap between the weld electrode and tubing being welded is open to the atmosphere, or a closed system in which this gap is enclosed. In either case, it is customary to flush the gap with a shielding gas for substantially eliminating oxygen from the vicinity of the weld and for carrying off any gases produced by the welding operation.

A variety of different gases have been used as shielding gases in conventional welding processes. Examples are the noble gases, especially argon, nitrogen and other gases. Nitrogen when used as a shielding gas in concentrations as low as 2% is known to enhance austenite formation in many different steels and so is a preferred choice in many applications. Hydrogen has also been used. In accordance with the present invention, however, it has

been found that nitrogen and hydrogen, in concentrations as low as 2%, cause an "explosion" of the weld pool created in the inventive process when a high refractory flux is present. Accordingly, hydrogen, nitrogen and all other gases having a similar effect are preferably avoided in carrying out the present invention. Thus, the shield gas used in this embodiment of the invention can include inert gases such as the noble gases (helium, argon, neon and xenon) as well as any other gas which does not react with the weld pool or the high refractory flux under the conditions encountered during welding.

The present invention will now be exemplified by a particular embodiment which is illustrated in the drawing:

Apparatus 10 for welding together tube ends 28 and 30 of duplex steel tubes 33 and 39 includes in a preferred embodiment an orbital welder device 12, a weld ring 14 and a flux material 16. The orbital welder may be, for example, an orbital welding system and power supply such as model M-100 available from Swagelok Company of Solon, Ohio. Other welding techniques well known to those of ordinary skill in the art can be used however, including but not limited to manual welding systems. In the exemplary embodiment, duplex steel tubes 33 and 39 are formed from SAF 2507 steel available from Sandvik Corporation of Sandviken, Sweden.

A weld filler material, such as for example, Alloy 25.10.4.L also available from Sandvik, is formed into a consumable insert or weld ring 14. Weld ring 14 is completely consumed in the weld puddle during the welding operation. A significant characteristic of Alloy 25.10.4.L is that it is over alloyed with nickel compared to the base metal being welded. The additional

nickel helps stabilize or enhance the austenite formation in the weld during solidification.

Alloy 25.10.4.L is commercially available in wire form from Sandvik Corporation. In accordance with one aspect of the invention, the filler wire is formed into a weld ring having a radial inner ring 20 and a circumferential axially extending ring 22 integral therewith. The weld ring 14 is appropriately dimensioned to slip onto each end of the tube ends being welded together. The weld ring 14 shape also aids in joint alignment which is particularly useful with orbital welding apparatus. Weld ring 14 can be formed by any convenient process such as by sintering, stamping and so forth.

Flux 16 is LFX-SS7 flux available from Liburdi Dimetrics. Other fluxes may be used as mentioned above. Preferably, flux 16 is applied to an outer surface 14a of the weld ring and on adjacent tube surfaces. Surface application facilitates the penetration enhancing characteristic of the flux. The flux 16 is typically available in powder form, but in this case is mixed with a liquid carrier to form a paste that is manually brushed on weld ring 14. The liquid carrier evaporates and the flux remains loosely adhered to the weld ring 14. The flux is preferably entirely consumed during the welding operation, however, flux residue can be easily cleaned from the final weldment as required. Preferably, the flux is kept near the outer surface of the weld ring 14, as shown in the figure.

Flux 16 improves heat penetration in the weld, thus reducing the weld width which reduces the potential for sagging and other weld profile problems that commonly occur during attempts to do a single pass welding operation with

thick walled components. By more efficiently directing the heat inward to reduce weld pool spread, the welding operation uses lower currents for full penetration. Reduced current allows for welding with smaller lower power weld heads and power supplies and also further aids in maintaining austenite in the weld.

In operation, the tube ends 28 and 30 of tube sections 33 and 39 are abutted together with weld ring 14 therebetween. Orbital welder 12 is used to perform a single pass welding operation using argon gas as the shield gas. For a typical duplex tube having a wall thickness of 0.095 inch and a tube diameter of 0.5 inch, acceptable welds are achieved using a welding current/voltage of 50 amps and 9 Volts at an electrode travel speed of 2.1 inches per minute. The weld bead produced in this manner has an austenite/ferrite ratio of 58/42 and a uniform profile along its entire width with a penetration characteristic (ratio of weld depth to maximum weld width) of 0.5.

The invention has been described with reference to the preferred embodiment. Obviously, modifications and alterations will occur to others upon a reading and understanding of this specification. It is intended to include all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

CLAIMS

We claim:

1. A process for welding duplex stainless steel parts comprising carrying out welding in the presence of a high refractory flux thereby forming a weld bead having a duplex stainless steel phase structure.

2. The process of claim 1, wherein the refractory flux comprises at least one of silica, titania, magnesia, chromia and TiO.

3. The process of claim 2, wherein the refractory flux comprises a mixture of Cr_2O_3, SiO_2 and an oxide of titanium.

4. The process of claim 1, wherein welding is accomplished by arc welding using a non-pulsed electrical arc.

5. A process comprising arc welding duplex stainless steel tubing using heat generated by a non-pulsed electric current in the presence of a refractory flux to form a weld bead with a duplex stainless steel phase structure and a uniform profile.

6. The process of claim 5, wherein the weld bead has a penetration characteristic of 0.33 or greater.

7. The process of claim 6, wherein the arc welding process is arc welding carried out in an enclosed system so as to shield the gap between the electrode producing the arc and the tubing being welded from atmospheric oxygen.

8. The process of claim 7, wherein the gap is flushed with a shield gas non-reactive with the weld pool and high refractory flux.

9. The process of claim 8, wherein the shield gas is inert gas helium, argon, neon zenon or mixtures thereof.

10. The process of claim 9, wherein additional alloying elements are supplied to the weld pool formed during welding by a weld filler having a higher nickel content than the metal forming the duplex steel to be welded.

11. The process of claim 8, wherein additional alloying elements are supplied to the weld pool formed during welding by a weld filler having a higher nickel content than the metal forming the duplex steel to be welded.

12. The process of claim 11, wherein the refractory flux comprises at least one of silica, titania, magnesia, chromia and TiO.

13. The process of claim 12, wherein the refractory flux comprises a mixture of Cr_2O_3, SiO_2 and an oxide of titanium.

14. The process of claim 8, wherein said welding step is completed in a single pass orbital weld.

15. The process of claim 14, wherein a weld ring formed from a weld filler material is placed between tube ends to be welded.

16. The process of claim 15, wherein the weld ring is T-shaped in cross section so that the ring can be slipped onto a tube end.

17. The process of claim 16, wherein the flux is applied to an outer surface of the weld ring.

18. The process of claim 5, wherein the refractory flux comprises at least one of silica, titania, magnesia, chromia and TiO.

19. The process of claim 14, wherein the refractory flux comprises a mixture of Cr_2O_3, SiO_2 and an oxide of titanium.

20. The process of claim 5, wherein said welding step is completed in a single pass orbital weld.

21. The process of claim 20, wherein a weld ring formed from a weld filler material is placed between tube ends to be welded.

22. The process of claim 21, wherein the weld ring is T-shaped in cross section so that the ring can be slipped onto a tube end.

23. The process of claim 22, wherein the flux is applied to an outer surface of the weld ring.

24. An insert for welding duplex stainless steel tubing, comprising:

a) a weld ring comprising higher % weight Ni compared to the duplex stainless steel tubing being welded; and

b) a penetration improving flux on an outer surface of said weld ring.

25. The insert of claim 24, wherein the flux is applied to an outer surface of the weld ring after the ring is formed.

26. The insert of claim 24, wherein said flux is part of the weld ring metal matrix.

27. The insert of claim 24, wherein said filler material comprises 25.10.4.L material.

28. The insert of claim 24, wherein said flux comprises a titanium oxide.

29. An orbital welding process for joining adjacent ends of two heavy wall duplex stainless steel tubes comprising

(a) placing a weld filler between the adjacent tube ends to be welded, the weld filler selected so that the weld bead formed by the welding process has a duplex phase structure,

(b) applying a high refractory flux to the heat affect zone formed by the weld filler and the adjacent tube ends to be welded, and

(c) arc welding the adjacent tube ends together in a single orbital pass using a non-pulsed arc.

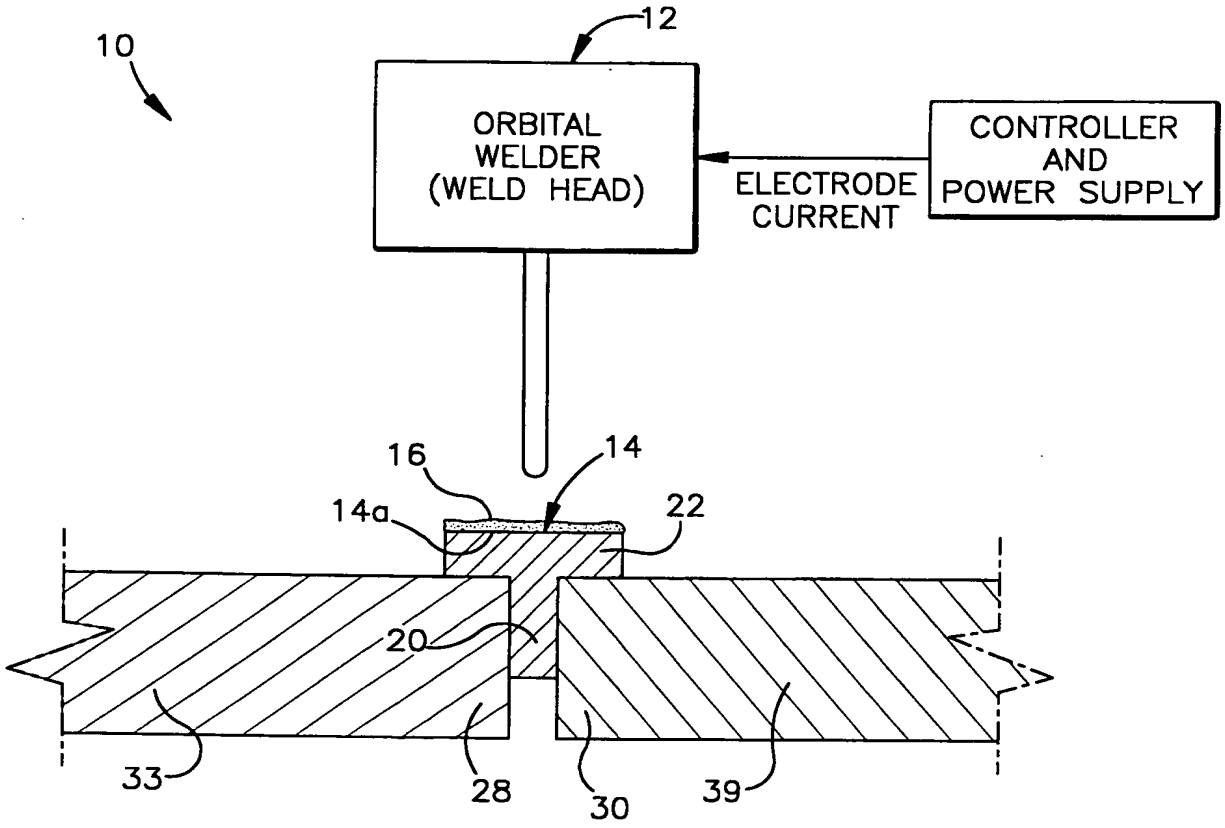
30. The process of claim 29, wherein the weld filler is made from a steel containing more austenite than the duplex steel tubes being welded together.

31. The process of claim 30, wherein the filler steel contains more nickel than the forming the duplex steel tubes being welded together.

32. The process of claim 29, wherein the flux includes a metal oxide.

33. The process of claim 29, wherein the weld filler is a weld ring having a T-shaped cross section.

34. The process of claim 29, wherein the arc is continuous.


10
12
ORBITAL WELDER (WELD HEAD)
CONTROLLER AND POWER SUPPLY
ELECTRODE CURRENT
16
14
14a
22
20
33
28
30
39

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/17414

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B23K 9/00
US CL :219/137WM, 136, 137R, 74, 75
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 219/137WM, 136, 137R, 74, 75

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

USPAT, EPO, JPO, Derwent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,711,474 A (HUMMEL) 27 January 1998, see entire document.	1-26 & 28-34
Y	US 5,804,792 A (PASKELL) 08 September 1998, see entire document	1-26 & 28-34
Y	US 4,952,769 A (ACHESON) 28 August 1990, see entire document	1-26 & 28-34
Y	US 4,683,011 A (WEAVER et al.) 28 July 1987, see entire document.	1-26 & 28-34
Y	US 4,338,142 A (OKUDA et al.) 06 July 1982, see entire document	1-26 & 28-34

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
29 SEPTEMBER 2000	17 OCT 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer M. ALEXANDRA ELVE DEBORAH THOMAS PARALEGAL SPECIALIST Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet) (July 1998)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/17414

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 27
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

IT IS NOT KNOWN WHAT IS MEANT BY 25.10.4.L MATERIAL.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.